Track 4:
Experimental and Applied Mechanics

Organized by:
Ryszard J. Pryputniewicz, *Worcester Polytechnic Institute;* John Lambros, *University of Illinois at Urbana-Champaign;* Hugh A. Bruck, *University of Maryland, College Park*

Experimental and Applied Mechanics covers the wide variety of subjects that are related to the broad field of experimental or applied mechanics. It is SEM's mission to disseminate information on a good selection of subjects. To this end, research and application papers in Track 4 relate to the broad field of experimental mechanics.

Keynote Presentations:

Dr. Akhlesh Lakhtakia, *Pennsylvania State University*
What is Needed to Excite Multiple Surface Plasmon Polariton Waves at a Given Frequency
Monday, June 7, 10:30 AM, Session 4

Sanichiro Yoshida, *Southeastern Louisiana University*
Strength Physics at Nano-scale and Application of Optical Interferometry
Monday, June 7, 1:30 PM, Session 11

Dr. Philip S. Whitehead, *Stresscraft Limited*
Practical Experiences in Hole Drilling Measurements of Residual Stresses
Tuesday, June 8, 1:30 PM, Session 32

Prof. I. Cevdet Noyan, *Columbia University*
Practical Experiences and Insights in Non-destructive Measurements of Applied and Residual Stresses
Thursday, June 10, 9:00 AM, Session 76

Keynote Presentation:

Akhlesh Lakhtakia
Pennsylvania State University

What is Needed to Excite Multiple Surface Plasmon Polariton Waves at a Given Frequency

Monday, June 7, 10:30 AM, Session 4

A variety of optical sensing mechanisms exist to detect anaytes present in water and other solvents. Themechanisms include: luminescence, fluorescence, phosphorescence, absorbance, elastic scattering, Ramanscattering, surface plasmon polaritons (SPPs), guided-wave resonance, and reflection/transmission due to planarinterfaces. SPP-based sensing technology has gained considerable following during the last two decades. Its basis isa quantum-electromagnetic resonance arising from the interaction of light with free electrons at the interface of ametal and a dielectric material. The classical analog of a train of SPPs is an SPP wave. Although several techniques exist to launch an SPP wave guided by the interface of a metal and an isotropic homogeneous dielectric material, the commonest way is to use the Kretschmann configuration. Both the metal and the dielectric material in this configuration are layers of finite thickness. The metal film's thickness is about 50 nm, whereas the dielectric layer has to be much thicker. On the other side of the metal film is a dielectric coupling material (in the form of a prism), which is optically denser than the dielectric material. Quasi-monochromatic light is launched at an angle to the thickness direction in the coupling material towards the metal film. The fraction of illuminating light that is neither reflected nor transmitted is absorbed. As the angle of incidence increases from 0deg, a sharp peak in absorbance, accompanied by minuscule reflectance and transmittance, indicates the excitation of an SPP wave. This sharp peak occurs only for p-polarized light, and only one SPP wave of a certain frequency can be excited. The basic characteristic of the excitation of only one SPP wave does not change when the isotropic homogeneous dielectric partner of the metal film is made anisotropic. A far more interesting possibility emergeswhen the anisotropic dielectric partnering material is a sculptured thin film (STF) that is periodically nonhomogeneous in the thickness direction. Remarkable characteristics of SPP-wave propagation guided by this kind of an interface have been found recently, both theoretically and experimentally. For application to optical sensing, the following conclusions are pertinent from the studies completed thus far: (i)A converging light beam with sufficient angular spread can be used to excite more than one SPP-wave modes simultaneously. (ii) The propagation speeds for all SPP-wave modes are different. (iii) The propagation lengths for all SPP-wave modes are different. (iv) Different slices of the STF, most likely in the first structural period closest to the metal, can be functionalized to promote attachment to different analytes for better discrimination.

Dr. Akhlesh Lakhtakia is the Charles Godfrey Binder (Endowed) Professor of Engineering Science and Mechanics at the Pennsylvania State University. He received his B.Tech. (1979) and D.Sc. (2006) degrees in Electronics Engineering from Banaras Hindu University, and his M.S. (1981) and Ph.D. (1983) degrees in Electrical Engineering from the University of Utah. He has published more than 645 journal articles; contributed 18 chapters to research books and encyclopedias; edited, co-edited, authored or coauthored 12 books and 8 conference proceedings; and reviewed for 110 journals. He was the Editor-in-Chief of the international journal *Speculations in Science and Technology* from 1993 to 1995, and is the founding Editor-in-Chief of the online *Journal of Nanophotonics* published by SPIE from 2007. He is a Fellow of the Optical Society of America, SPIE, and the Institute of Physics (UK). At Penn State, he was awarded the PSES Outstanding Research Award in 1996, the Faculty Scholar Medal in Engineering in 2005, and the PSES Premier Research Award in 2008. His current research interests lie in the electromagnetic of complex mediums, sculptured thin films, and nanotechnology.

Keynote Presentation:

Sanichiro Yoshida
Southeastern Louisiana University

Strength Physics at Nano-scale and Application of Optical Interferometry

Monday, June 7, 1:30 PM, Session 11

Dynamics in the nano-scale regime is unique; it is too small to apply conventional mechanics and too large to apply quantum mechanics. No comprehensive theory is available to explain material properties and interactions at this scale. A number of experimental observations remain unexplained, and often nano-systems fabricated based on conventional design methods do not meet the expected requirement in strength. To better describe strength physics at the nano-scale, an effort has been made to develop a theory of plastic deformation and fracture based on an ab initio approach. A fundamental physical principle known as local symmetry is applied to extend the theory of elasticity to other stages of deformation. To acquire supporting data for the theoretical development, optical interferometry has been used to measure displacement. Optical interferometry is advantageous at a small scale because the measurement is based on the phase, not amplitude, of the optical field; consequently, the resolution is not limited by the wavelength. In this talk, basics of the above-mentioned ab initio approach to deformation and fracture mechanics will be presented, and application of optical interferometry to measurement of displacement and strain at the nano-scale will be discussed.

Sanichiro Yoshida received his undergraduate, Master's and Doctoral degrees from Keio University. Presently he is with Southeastern Louisiana University. He conducts various researches in the fields of optics and material science. He is especially interested in developing a general theory of deformation capable of describing deformation and fracture comprehensively, and applicable to any scale level universally. He uses optical interferometry to characterize mechanical properties of materials.

Keynote Presentation:

Philip S. Whitehead
Stresscraft Limited

Practical Experiences in Hole Drilling Measurements of Residual Stresses

Tuesday, June 8, 1:30 PM, Session 32

Strain gauge hole drilling is one of the most widely used destructive methods for measuring residual stresses. This paper describes hole drilling at Stresscraft from 1987 to the present day. Early procedures consisted of simple installations at readily accessible sites. In subsequent years, demands increased for hole drilling on more diverse component shapes and materials. Critical details of the methodology required for credible and reliable measurements are identified and discussed. These include strain measurements, the hole forming process and strain-to-stress calculation procedures. Developments were made to improve the reproducibility and reliability of the method and accessibility at difficult target sites. Significant developments have included implementation of the Integral Method in 1989 (after G. S. Schajer) and the introduction of PC-controlled miniature 3-axis drilling machines for orbital drilling in 1999. Two machines have been used over a 10-year period to drill approximately 15,000 gauges. While the fundamental elements of the method remain unchanged, in extreme cases, gauges can now be installed and drilled at sites that can only be viewed using miniature cameras. A number of examples of installations and results are presented and discussed to demonstrate the development of the method.

Dr. Philip S. Whitehead received his First degree in the Mechanical Engineering Department at University of Nottingham; 1st class Hons. BSc. in 1974. From 1974–1975 he was Development Engineer with Formula 1 racing team; British Racing Motors (BRM). During 1975-1978 he worked towards his PhD in the Mechanical Engineering Department at University of Nottingham focusing on research in photoelastic stress analysis applied to diesel engine crankcase structures; supervisor, Prof. Henry Fessler. Dr. Whitehead worked as Research Engineer at Stress Analysis Ltd, Melbourne, Derby, during 1978-1984 working on the photoelastic stress analysis of engineering components. He formed the company 'Stresscraft' in 1984 (became Stresscraft Ltd in 1987) focusing on the determination of residual stresses in engineering components using the target gauge/centre hole drilling method (from ca. 1987 onwards).

Keynote Presentation:

I. Cevdet Noyan
Columbia University

Practical Experiences and Insights in Non-destructive Measurements of Applied and Residual Stresses

Thursday, June 10, 9:00 AM, Session 76

In this seminar I will discuss the application of x-ray and neutron diffraction techniques for applied and residual strain measurement to problems of industrial importance over two size ranges. During the first part I will present our recent neutron measurements on the partitioning of applied stresses within the individual wires of a suspension bridge wire strand. These wires have significant residual stresses due to spooling, and I will also cover mechanical techniques that can be used to determine these residual stresses. In the second part of the talk I will discuss the importance of residual stresses in microelectronics, and show examples from microbeam x-ray measurements of strains within ULSI chips.

Professor I. Cevdet Noyan is Vice-chair of the Department of Applied Physics and Applied Mathematics, and holds a joint appointment in the Department of Earth and Environmental Engineering, at Columbia University, Fu School of Engineering and Applied Science. He and his group have been working on the theory of x-ray & neutron diffraction from crystalline materials, and the application of diffraction analysis to the characterization of mechanical and micromechanical deformation for more than twenty five years . He is the author of more than one hundred papers and a monograph in this area. Professor Noyan is a Fellow of the American Physical Society, co-editor of Advances in X-Ray Analysis, and Organizing Committee Member of the Denver X-Ray Conference.